

PATENT COOPERATION TREATY

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NOTIFICATION CONCERNING
AMENDMENTS OF THE CLAIMS(PCT Rule 62 and
Administrative Instructions, Section 417)

From the INTERNATIONAL BUREAU

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Applicant

MOTOROLA LIMITED et al

The International Bureau hereby informs the International Preliminary Examining Authority that no amendments under Article 19 have been received by the International Bureau (Administrative Instructions, Section 417).

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PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

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Applicant AFTELAK, Andrew, John	

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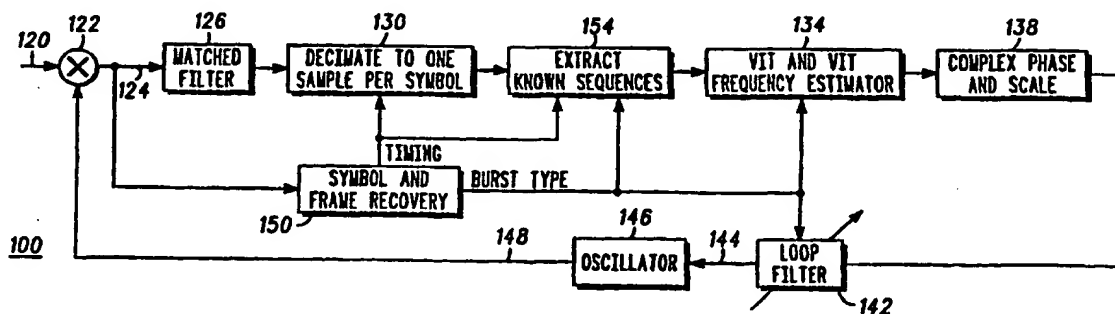
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(21) International Application Number: PCT/EP00/01734 (22) International Filing Date: 25 February 2000 (25.02.00) (30) Priority Data: 9904437.2 26 February 1999 (26.02.99) GB (71) Applicant (for all designated States except US): MOTOROLA LIMITED [GB/GB]; Jays Close, Viables Industrial Estate, Basingstoke, Hampshire RG22 4PD (GB). (72) Inventor; and (75) Inventor/Applicant (for US only): AFTELAK, Andrew, John [GB/GB]; 54 Ivor Gardens, Lychpit, Basingstoke, Hampshire RG24 8YD (GB). (74) Agents: LITCHFIELD, Laura et al.; Motorola European Intellectual Property Operations, Midpoint, Alencon Link, Basingstoke, Hampshire RG21 7PL (GB).		(81) Designated States: AU, BR, CA, CN, CZ, HU, IL, IN, JP, NO, PL, SG, SI, US, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: FREQUENCY TRACKING LOOP AND METHOD OF FREQUENCY TRACKING



(57) Abstract

The invention comprises a frequency tracking loop and method of frequency tracking for a digital radio communications system. The invention also extends to a digital radio communications receiver which comprises a frequency tracking loop in accordance with the invention, and a mobile- or a portable radio, or a mobile telephone, comprising such a receiver. The frequency tracking loop (100) comprises: a mixer (122) for correcting frequency offset of an input radio signal comprising bursts of known data; a frequency offset estimator (134), for providing an estimate of frequency offset; a variable bandwidth filter (142), for providing a filtered signal; an oscillator (146) for supplying the second input of the mixer with a signal whose frequency depends on the filtered signal; the frequency tracking loop (100) is adapted to change the bandwidth of the variable bandwidth filter (142) in dependence on at least one characteristic of the currently received burst of known data. The frequency tracking loop (100) may be adapted to change the bandwidth of the variable bandwidth filter (142) in dependence on the length of the currently received burst of known data. The burst of data may be a training sequence. The frequency tracking loop and method provide optimum bandwidth for tracking a radio signal which may suffer variable offsets from a nominal frequency value.

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Frequency Tracking Loop and Method of Frequency Tracking

Technical Field

- 5 The present invention relates to the field of radio communication systems. Particularly, but not exclusively, this invention relates to radio receivers for mobile digital radio communication systems.

Background

- 10 Mobile radio communications systems generally comprise a number of mobile or portable radio units. The radio units in a public- or private mobile radio communications system are often referred to as 'mobile stations'. The radio communication system's infrastructure comprises fixed nodes, termed 'base stations', through which mobile stations can communicate.

- 15 Normally, a mobile station is within communication range of a base station. In this case, the mobile station will communicate through the base station, this mode of operation typically being termed 'trunked mode'. However, some mobile radio communication systems allow an individual mobile station to set up
20 a direct radio link to another mobile station, without the communication link passing through the infrastructure of the communication system. This form of communication between two mobile stations is referred to as 'direct mode' operation.

- 25 Mobile stations operating in direct mode have to receive radio signals that typically show greater variation in their parameters than radio signals received from the infrastructure of the communications system. This is because of differences in the signals transmitted from a mobile station in comparison to those from a base station of the infrastructure. As an example, the lower quality
30 clock of a mobile station may cause greater variation in the carrier frequency of the signal broadcast by the mobile station in comparison to that from a base station.

- 35 The information carried by any digital communications system can only be recovered after the receiver has first synchronised to the received signal. The high frequency signal reaching the receiver will be at a frequency that depends on the frequency of an oscillator in the transmitter. A further oscillator in the

receiver is used to down-convert the high frequency received signal. Because the oscillators in the transmitter and the receiver do not work at precisely the same frequency, the down-converted signal in the receiver has a slightly different frequency than that which would arise if the two oscillators had

5 identical frequencies. This mismatch is part of the reason why a synchronisation circuit is needed in the receiver, to 'compensate' for the down-converted signal not having its ideal, theoretical frequency value. The mismatch will typically vary with time.

10 Thus there is a need in a mobile digital radio system for synchronisation in the radio receiver. The state where synchronisation between the receiver and the received signal has been attained is often referred to simply as 'lock'. The need for accurate synchronisation is particularly great for direct mode operation of mobile stations, because of the greater variation in the parameters of the
15 received radio signals. This applies both to:
(i) achieving synchronisation when a call is first set up; and
(ii) maintaining synchronisation during a call.

In the Terrestrial Trunked radio system (TETRA), direct mode operation is
20 permitted. A direct mode call is set up by sending two frames (8 slots) of synchronisation bursts, which last for 113 msec. In terms of the requirements on the automatic frequency correction (AFC) algorithm in the receiving radio, the radio needs to synchronise to these bursts, in order to start decoding data as quickly as possible. After synchronisation at call set up, the receiver must then
25 maintain synchronisation for the duration of the call. This requires the receiver to follow variations in the frequency of the received signal. This action of following is often referred to as 'tracking'. The part of the receiver which carries this out is the 'tracking loop'.

30 The synchronisation bursts are an example of a 'training sequence'. A 'training sequence' is a sequence of symbols in a communications signal which are known to both the transmitter and the receiver.

Figure 1 shows a prior art arrangement of a frequency tracking loop 10. This is
35 a 'feedback' tracking loop. Figure 1 shows a generalised arrangement in order to explain the principle of operation of a frequency tracking loop.

Briefly, the elements shown in figure 1 are:

- 5 (i) A mixer 22. One input to the mixer, element 20, provides the radio signal received by the receiver, which may have been 'down-converted' to intermediate frequency. This down-converted signal is the 'input' to the frequency tracking loop. The oscillator used to down-convert the received high frequency signal to intermediate frequency is not shown in figure 1. It is however this oscillator which is partly responsible for frequency variations in the input signal. The output of the mixer is provided on output 24.
- 10 (ii) A 'data matched' filter 26. The filter is matched to the pulse shape of the received signal. This means that it is designed to filter pulses of the shape transmitted by the transmitter of the radio system.
- 15 (iii) A decimation circuit 30. The decimation circuit 30 reduces the number of samples supplied to it from the filter 26. Decimation circuit 30 reduces the number of samples to one per received pulse. This is enough to identify each received pulse.
- 20 (iv) A Viterbi & Viterbi Frequency estimator 34. This is a known circuit element, which implements a known method of measuring frequency offset. Estimator 34 uses the training sequences in making the estimate of frequency offset. Other prior art arrangements are however known which do not rely on the training sequences to achieve this.
- 25 (v) A complex phase determining and scaling circuit 38.
- (vi) A loop filter 42.
- 30 (vii) An oscillator 46. The output of oscillator 46 is fed back on output 48 to provide the second input to mixer 22.

35 The purpose of the circuit shown in figure 1 is to 'track' variations in the frequency of the input signal. Elements (ii)-(vi) drive oscillator 46 to generate a signal which matches the frequency of the input signal. As there is a time delay in the oscillator generating a signal that has the same frequency as the input to

the frequency tracking loop, the 'following' action provided by the whole frequency tracking loop is not instantaneous.

5 In operation of the feedback tracking loop, the frequency estimator 34 and phase and scaling block 38 give an estimate of the frequency offset from the current input. This estimate will be noisy.

The noisy estimates are passed through the loop filter 42, which reduces the noise and defines the transient response of the frequency tracking loop 10.

10

The bandwidth chosen for the loop filter 42 is a compromise between two requirements. One of these is the requirement to reject noise. This dictates that the loop filter 42 have a narrow bandwidth. The other requirement is that the frequency tracking loop 10 be able to track a changing input frequency. This
15 dictates that the loop filter 42 have a wide bandwidth. Clearly these requirements set conflicting conditions on the loop filter 42.

Frequency tracking loops of the prior art are known, which switch the bandwidth of the tracking filter during acquisition of a signal. A wide bandwidth is used to
20 acquire the signal, and the bandwidth of the loop filter is narrowed during tracking.

Frequency tracking loops are also known in the prior art which adapt the loop filter bandwidth in dependence on the size of the estimate of frequency.
25 However, adaptation of the loop is based on the measurement of the error between the currently received and currently generated frequencies. This measurement itself may be in error and can lead to an adaptation that suppresses the wanted signal.

30 A need exists to alleviate problems of the arrangements known from the prior art. One particular problem addressed by the present invention is to provide optimum frequency tracking in a feedback tracking loop.

Summary of the Invention.

The invention comprises a frequency tracking loop for a digital radio communications system. The frequency tracking loop comprises:

5

(i) a means for correcting frequency offset, the means for correcting frequency offset receiving an input radio signal comprising bursts of known data at a first input, and supplying an output signal;

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(ii) a frequency offset estimator, supplied with the output signal from the means for correcting frequency offset, for providing an estimate of the frequency offset of the output signal;

15

(iii) a variable bandwidth filter, supplied with the estimate of the frequency offset from the frequency offset estimator, for providing a filtered signal;

20

(iv) a signal generating means, supplied with the filtered signal from the variable bandwidth filter, for generating an output signal with a frequency dependent on the filtered signal, the output signal from the signal generating means being supplied to a second input of the means for correcting frequency offset, wherein the frequency tracking loop is adapted to change the bandwidth of the variable bandwidth filter in dependence on at least one characteristic of the currently received burst of known data.

25

The frequency tracking loop may be adapted to change the bandwidth of the variable bandwidth filter in dependence on the length of the currently received burst of known data.

30

The invention also extends to a digital radio communications receiver which comprises a frequency tracking loop in accordance with the invention, and a mobile- or a portable radio, or a mobile telephone, comprising such a receiver.

The invention also comprises a method of frequency tracking for a digital radio communications system. The method of frequency tracking comprises:

- 5 (i) in a means for correcting frequency offset, receiving an input radio signal comprising bursts of known data;
- (ii) estimating the frequency offset of the output signal from the means for correcting frequency offset, to provide an estimate of frequency offset;
- 10 (iii) filtering the estimate of frequency offset with a variable filtering bandwidth, to provide a filtered signal;
- (iv) generating a signal having a frequency dependent on the filtered signal, to
15 provide a generated signal;
- (v) correcting the frequency of the input radio signal in the means for correcting frequency offset, using the generated signal;
- 20 wherein the variable filtering bandwidth depends on at least one characteristic of the currently received burst of known data.

The method of frequency tracking may further comprise changing the bandwidth of the variable bandwidth filtering in dependence on the length of the currently
25 received burst of known data.

The invention provides an adaptive frequency tracking loop and method of frequency tracking, which have optimised frequency tracking. This tracking provides rapid and precise automatic frequency control within the feedback
30 tracking loop in response to changes in the input frequency to the loop. The adaptive loop has better performance than conventional techniques. The frequency tracking loop has a better chance than prior art circuits of maintaining lock when the signal level is low.

35 The invention is particularly advantageous for a digital radio communications receiver operating in direct mode.

Brief description of the drawings

Figure 1 illustrates a prior art frequency tracking loop.

5

Figure 2 illustrates in detail one embodiment of a frequency tracking loop in accordance with the invention.

Figure 3 illustrates one embodiment of a method of frequency tracking in accordance with the invention, in the form of a flow chart.

10

Detailed description of the preferred embodiment

Figure 2 illustrates one embodiment of a frequency tracking loop in accordance with the invention. The frequency tracking loop of figure 2 is an adaptive loop.

15 The circuit of figure 2 is a frequency tracking loop 100 for a digital radio communications system. The input to the frequency tracking loop is a received radio signal. The signal input to the frequency tracking loop may have been converted into an intermediate frequency signal and then to base-band prior to reaching frequency tracking loop 100. Alternatively, the input signal may have
20 been directly converted from high frequency down to base-band in a direct converter. The input radio signal comprises bursts of known data. In a TETRA or GSM signal, these bursts of known data are the training sequences.

The received radio signal is supplied to the first input 120 of a mixer 122 in the
25 embodiment of figure 2. However, other means for correcting frequency offset, such as for example a complex multiplier, could be used here. Mixer 122 supplies an output signal on output 124.

The signal on output 124 is fed to matched filter 126, and then to a decimation
30 circuit 130.

After decimation, the signal may be fed to circuit element 154. Element 154 serves to extract the training sequences from the signal. These training sequences are used by element 134, a Viterbi & Viterbi Frequency estimator.

Frequency estimator 134 provides an estimate of the frequency offset of the output signal from the mixer. An element corresponding to element 154 may also be used in the prior art arrangement of figure 1, but was not shown there for reasons of clarity of illustration.

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The estimate of the frequency offset is fed to a complex phase and scale circuit 138, and then to a variable bandwidth filter 142. The variable bandwidth filter 142 provides a filtered signal on output 144.

10 The filtered signal on output 144 is fed to an oscillator 146. Typically, oscillator 146 is a voltage controlled oscillator. However, any signal generating means that is suitable for generating an output signal with a frequency that depends on the filtered signal could be used here.

15 The output signal from oscillator 146 is supplied to a second input 148 of the mixer 122. This enables mixer 122 to correct the frequency of the input signal on input 120.

20 The frequency tracking loop of the invention is adapted to change the bandwidth of the variable bandwidth filter 142 in dependence on at least one characteristic of the currently received burst of known data. In accordance with the invention, the frequency tracking loop automatically adapts the bandwidth of the loop filter 142. Therefore the frequency tracking loop is 'adaptive'.

25 In the particular arrangement shown in figure 2, means 150 provide symbol and frame timing information to the whole frequency tracking loop 100. In accordance with the invention, means 150 determines the type of burst of known data received in a slot of the input radio signal. Means 150 can then supply a signal to the variable bandwidth filter 142 identifying the type of burst of known data. The
30 type of burst indicates how many a priori known data symbols are contained within the burst. This information allows adjustment of the bandwidth of the variable bandwidth loop filter on the basis of the length of known data within the received burst.

35 The effect of varying the bandwidth of variable bandwidth filter 142 in accordance with the invention can be understood by considering the operation of

frequency estimator 134. As explained in connection with figure 1, the frequency estimator 34, 134 in the frequency tracking loop derives an estimate of the frequency of the signal output by the mixer. The frequency estimator 134 in the arrangement of figure 2 uses the training sequences to make this estimate.

5

The signal to noise ratio of the frequency estimate provided by frequency estimator 134 is approximately proportional to the number of known symbols used to derive the estimate. Therefore the bandwidth of the variable bandwidth loop filter can be optimised to the signal to noise ratio of the output signal from the frequency estimator 134 by changing the bandwidth in dependence on the number of symbols in the received known data sequence. As explained in detail below, the TETRA and GSM systems use training sequences whose type indicates the number of symbols which they contain.

10

Various detailed arrangements of the invention satisfy the underlying principle of the invention. The invention may be arranged with a frequency tracking loop that is adapted to provide a variable bandwidth filter with a relatively wide bandwidth on receiving a long burst of known data, and a relatively narrow bandwidth on receiving a short burst of known data. The bandwidth may be made proportional to the length of the currently received burst of known data.

20

The function of circuit element 150 is now considered. A receiver of digital data normally has circuitry for recovering the symbols and frames of the received signal. This circuitry provides symbol and frame timing information to the receiver. In fact, the training sequences in the received signal are normally used to facilitate this recovery. Typically, the bits of the known training sequence are compared in a correlator with each successive group of bits of the received radio signal. When the correlation is a maximum, this indicates that the group of bits of the received signal corresponds to the training sequence. Since the receiver knows where in a frame of data the training sequences are located, this correlation technique provides the required information about the start and finish of the frame, and hence the frame timing. In making the correlation determination, the correlator clearly also identifies which type of training sequence is contained in the received radio signal. Therefore element 150 can provide both information about the timing of the training sequences to element

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30

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134 in figure 2, and information about the specific type of training sequence received to variable bandwidth filter 142.

Although figure 2 shows a specific arrangement for implementing the teaching of the present invention, the invention is of wider scope than this single embodiment. In the arrangement shown in figure 2, means 150 supplies information about the type of burst to the loop filter 142. However, means 150 may simply determine the number of symbols making up the burst of known data. Means 150 could then supply this information to the variable bandwidth filter 142. Alternatively, means 150 could supply a control signal to the variable bandwidth filter, setting the bandwidth of the filter in dependence on the number of known symbols contained within the burst. The number of symbols and their location is defined by the type of burst, which is determined by identifying the training sequence.

GSM and TETRA radio systems are now considered, in order to provide a numerical example of a practical implementation of the invention. Both GSM mobile telephone systems and TETRA radio systems employ training sequences. Motorola's TETRA compliant radio system is the 'Dimetra' system. When Dimetra subscribers operate in direct mode, the automatic frequency control loop derives its estimate of frequency offset from the training sequences in the received bursts.

TETRA direct mode communication uses two types of training sequence, i.e. bursts of known data, during a call. These are the 'synchronisation burst' (DSB) and the 'normal burst' (DNB).

For the DSB burst, the known training sequences are a 6 symbol preamble, a 19 symbol training sequence and a 40 symbol frequency correction sequence. The data burst therefore comprises a total of 65 symbols.

For the DNB burst, the known training sequences are a 6 symbol preamble and an 11 symbol training sequence. The data burst therefore comprises a total of 17 symbols.

Therefore we can expect estimates derived from the DSB bursts to have an average signal to noise ratio 65/17 times better than the estimates derived from the DNB bursts.

- 5 In the particular example of a TETRA system, the inventive frequency tracking loop can adjust the bandwidth of the loop filter in dependence on whether either a DSB or a DNB has been received.

- 10 When a DSB has been received, the loop bandwidth can be made wider than for a DNB, for example 65/17 times wider. The noise performance of the loop will not suffer significantly, but its ability to track changing frequencies will be enhanced.

- 15 The arrangement of the invention is valid for other lengths of data burst than the example of DSB and DNB data bursts explained here.

- 20 This example provided a bandwidth for the variable frequency filter which was 65/17 times wider in the case of a DSB burst than a DNB burst. However, the invention extends to other tracking loops, particularly those with a filter bandwidth for a larger burst that is greater than the bandwidth for a smaller burst by a factor equal to the ratio of the number of symbols in two different types of known data burst.

- 25 The frequency tracking loop may advantageously be used in a receiver for a digital radio communications system. The receiver incorporating the frequency tracking loop of the invention may be employed in a mobile- or a portable radio, or a mobile telephone.

- 30 Figure 3 shows a method of frequency tracking in accordance with the invention, in the form of a flow-chart 300.

The method of frequency tracking of figure 3 for a digital radio communications system comprises steps 310-350.

- 35 In step 310, a means for correcting frequency offset receives an input radio signal comprising bursts of known data. These bursts of known data are typically

the TETRA training sequences explained above. The means for correcting frequency offset may comprise, for example, a mixer or a complex multiplier.

5 Step 320 of the method comprises estimating the frequency offset of the output signal from the means for correcting frequency offset. This step provides an estimate of frequency offset of the received radio signal.

10 In step 330, the estimate of frequency offset is filtered with a variable filtering bandwidth, to provide a filtered signal. The variable filtering bandwidth used depends on at least one characteristic of the currently received burst of known data.

15 Step 340 comprises generating a signal having a frequency dependent on the filtered signal from step 330, to provide a generated signal. Typically, an oscillator may generate this signal.

Step 350 comprises correcting the frequency of the input radio signal in the means for correcting frequency offset, using the signal generated in step 340.

20 Although step 350 is shown separately from step 310 in figure 3, these steps are both performed in the mixer. See element 122 of figure 2. Once a first estimate of the frequency offset has been found therefore, step 350 can be considered to link back into step 310. This is not illustrated in figure 3 for simplicity.

25 In further preferred embodiments of the method of the invention, step 330 may further comprise changing the bandwidth of the variable bandwidth filtering in dependence on the length of the currently received burst of known data. The change of bandwidth may be such as to provide variable bandwidth filtering with a relatively wide bandwidth on receiving a long burst of known data, and
30 providing variable bandwidth filtering with a relatively narrow bandwidth on receiving a short burst of known data. The bandwidth of the variable bandwidth filter may be made proportional to the length of the currently received burst of known data.

35 The frequency tracking loops and methods of the prior art do not make use of the expected signal to noise ratio of the individual estimates of frequency offset,

based upon the type of input data burst, to adapt the bandwidth of the loop filter. Thus these prior art arrangements do not have the advantage of the invention, that the tracking performance is improved without impacting on robustness to noise.

Claims

1. A frequency tracking loop for a digital radio communications system, the frequency tracking loop comprising:
- 5 (i) a means for correcting frequency offset, the means for correcting frequency offset receiving an input radio signal comprising bursts of known data at a first input, and supplying an output signal;
- (ii) a frequency offset estimator, supplied with the output signal from the means for correcting frequency offset, for providing an estimate of the frequency offset
- 10 of the output signal;
- (iii) a variable bandwidth filter, supplied with the estimate of the frequency offset from the frequency offset estimator, for providing a filtered signal;
- (iv) a signal generating means, supplied with the filtered signal from the variable bandwidth filter, for generating an output signal with a frequency dependent on
- 15 the filtered signal, the output signal from the signal generating means being supplied to a second input of the means for correcting frequency offset, wherein the frequency tracking loop is adapted to change the bandwidth of the variable bandwidth filter in dependence on at least one characteristic of the currently received burst of known data.
- 20
2. A frequency tracking loop in accordance with claim 1, wherein the means for correcting frequency offset comprise a mixer or a complex multiplier, and the signal generating means comprise an oscillator.
- 25
3. A frequency tracking loop in accordance with claim 1 or claim 2, wherein the frequency tracking loop is adapted to change the bandwidth of the variable bandwidth filter in dependence on the length of the currently received burst of known data.
- 30
4. A frequency tracking loop in accordance with any previous claim, wherein the frequency tracking loop is adapted to provide the variable bandwidth filter with a relatively wide bandwidth on receiving a long burst of known data, and to provide the variable bandwidth filter with a relatively narrow bandwidth on receiving a short burst of known data.

5. A frequency tracking loop in accordance with any previous claim, wherein the frequency tracking loop is adapted to provide the variable bandwidth filter with a bandwidth proportional to the length of the currently received burst of known data.

5

6. A frequency tracking loop in accordance with any previous claim, wherein the bursts of known data comprise one or more synchronisation bursts and one or more normal bursts, the frequency tracking loop being adapted to provide the variable bandwidth filter with a larger bandwidth for the

10 synchronisation burst than for the normal burst, the bandwidth for the synchronisation burst being larger than that for the normal burst by a factor equal to the ratio of the number of symbols in the synchronisation and normal bursts.

7. A frequency tracking loop in accordance with claim 1 or claim 2,

15 further comprising means for:

(i) determining the type of burst of known data received in a slot of the input radio signal; and

(ii) supplying a signal to the variable bandwidth filter identifying the type of burst of known data.

20

8. A frequency tracking loop in accordance with claim 1 or claim 2, further comprising means for:

(i) determining the type of burst of known data and the number of symbols making up the burst of known data; and

25 (ii) supplying a control signal to the variable bandwidth filter setting the bandwidth of the filter in dependence on the number of symbols.

9. A receiver for a digital radio communications system, the receiver comprising a frequency tracking loop in accordance with any previous claim.

30

10. A mobile- or a portable radio, or a mobile telephone, comprising a receiver in accordance with claim 9.

11. A method of frequency tracking for a digital radio communications system, the method of frequency tracking comprising:

(i) in a means for correcting frequency offset, receiving an input radio signal comprising bursts of known data;

5 (ii) estimating the frequency offset of the output signal from the means for correcting frequency offset, to provide an estimate of frequency offset;

(iii) filtering the estimate of frequency offset with a variable filtering bandwidth, to provide a filtered signal;

10 (iv) generating a signal having a frequency dependent on the filtered signal, to provide a generated signal;

(v) correcting the frequency of the input radio signal in the means for correcting frequency offset, using the generated signal;

wherein the variable filtering bandwidth depends on at least one characteristic of the currently received burst of known data.

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12. A method of frequency tracking in accordance with claim 11, further comprising changing the bandwidth of the variable bandwidth filtering in dependence on the length of the currently received burst of known data.

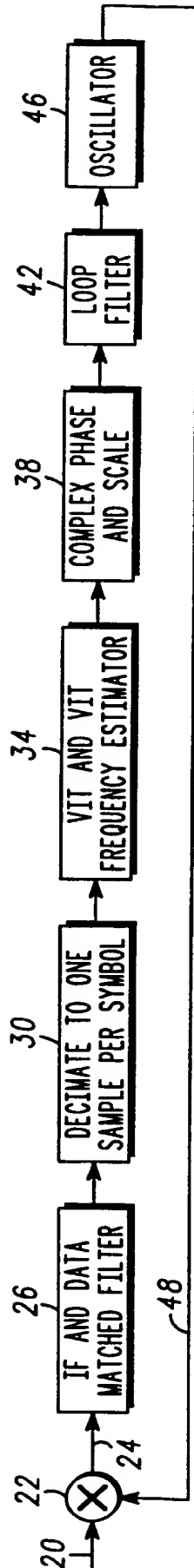
20 13. A method of frequency tracking in accordance with claim 11 or claim 12, further comprising providing variable bandwidth filtering with a relatively wide bandwidth on receiving a long burst of known data, and providing variable bandwidth filtering with a relatively narrow bandwidth on receiving a short burst of known data.

25

14. A method of frequency tracking in accordance with any of claims 11-13, further comprising providing the variable bandwidth filter with a bandwidth proportional to the length of the currently received burst of known data.

30 15. A frequency tracking loop for a digital radio communications system substantially as hereinbefore described with reference to, or as illustrated by, figure 2 of the drawings.

1/2



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FIG. 1

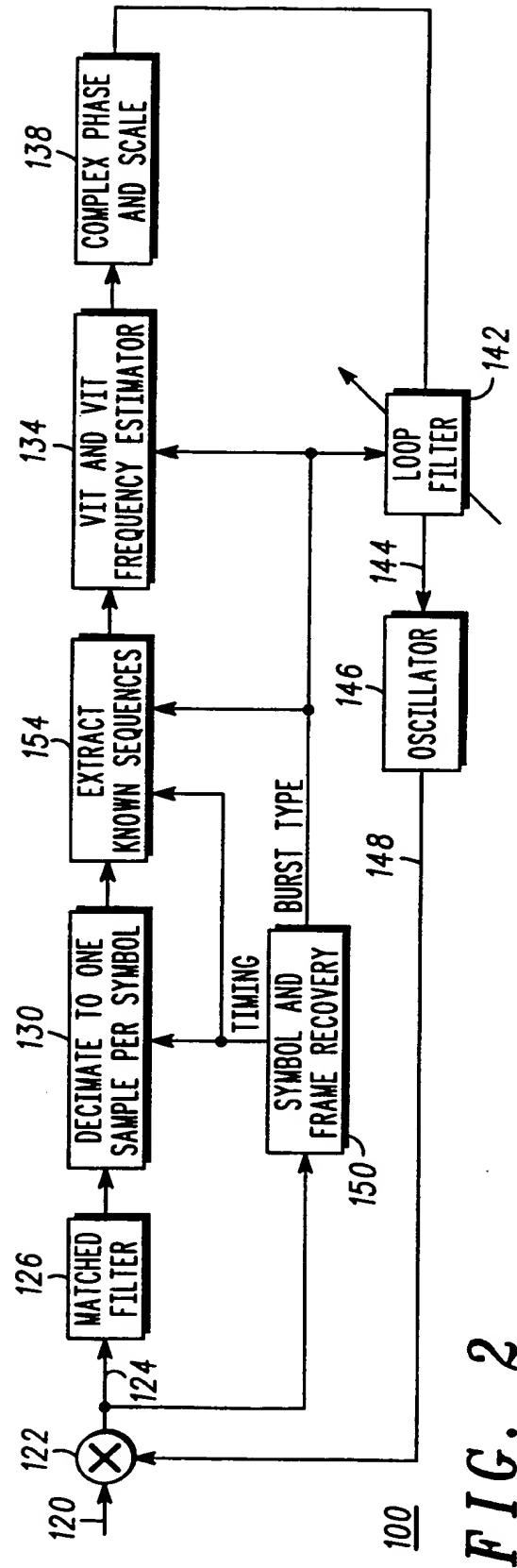
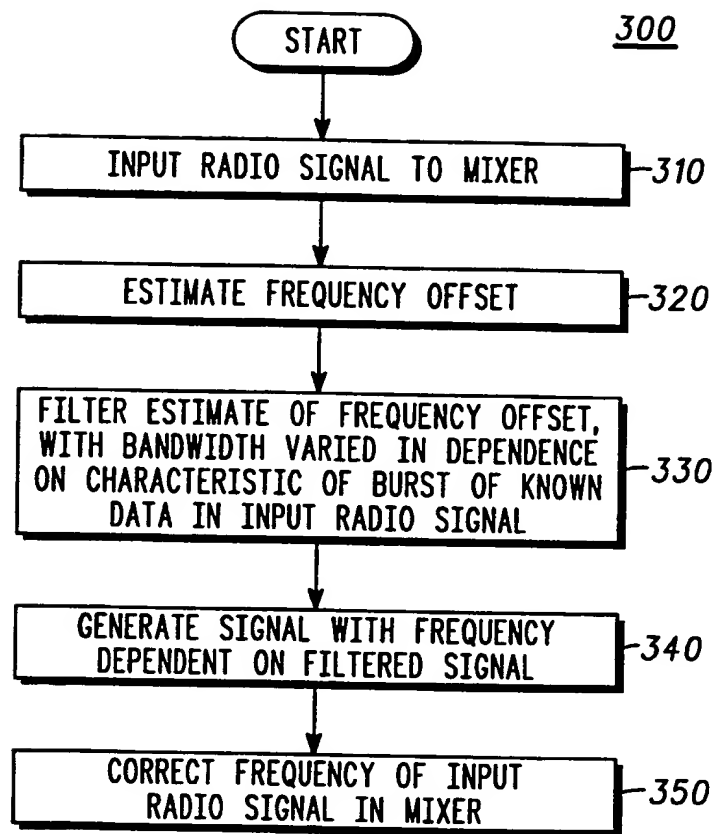


FIG. 2

**FIG. 3**

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/01734

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H03J7/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H03J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 691 176 A (HSIUNG CHIA Y ET AL) 1 September 1987 (1987-09-01) column 5, line 37 - line 47 ---	1,2,11
A	US 4 674 103 A (CHEVILLAT PIERRE R ET AL) 16 June 1987 (1987-06-16) abstract ---	1,3, 11-13
A	US 5 199 047 A (KOCH WOLFGANG) 30 March 1993 (1993-03-30) column 4, line 21 - line 46 -----	3,12,13

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

4 August 2000

Date of mailing of the international search report

11/08/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Peeters, M

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/EP 00/01734

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4691176 A	01-09-1987	NONE	
US 4674103 A	16-06-1987	EP 0211995 A	04-03-1987
		DE 3574320 D	21-12-1989
		JP 1792287 C	14-10-1993
		JP 4076542 B	03-12-1992
		JP 62049730 A	04-03-1987
US 5199047 A	30-03-1993	DE 4001592 A	02-05-1991
		DE 59010213 D	25-04-1996
		EP 0428199 A	22-05-1991
		JP 3208421 A	11-09-1991

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference CM00565P/PCT	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 01734	International filing date (day/month/year) 25/02/2000	(Earliest) Priority Date (day/month/year) 26/02/1999
Applicant MOTOROLA LTD. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

2

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 00/01734

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H03J7/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H03J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 199 047 A (KOCH WOLFGANG) 30 March 1993 (1993-03-30) column 4, line 21 - line 46 -----	3,12,13

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

4 August 2000

Date of mailing of the international search report

11/08/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Peeters, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/01734

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4691176	A	01-09-1987	NONE	
US 4674103	A	16-06-1987	EP 0211995 A	04-03-1987
			DE 3574320 D	21-12-1989
			JP 1792287 C	14-10-1993
			JP 4076542 B	03-12-1992
			JP 62049730 A	04-03-1987
US 5199047	A	30-03-1993	DE 4001592 A	02-05-1991
			DE 59010213 D	25-04-1996
			EP 0428199 A	22-05-1991
			JP 3208421 A	11-09-1991



Application No: GB 9904437.2
Claims searched: 1-15

Examiner: Brian Ede
Date of search: 23 July 1999

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3A(AD, AN, ARX, ASD, ASL, ASX, AXC, AXX)

Int Cl (Ed.6): H03L 7/00 7/08 7/093 7/107 H04L 27/227

Other: Online: EPODOC; JAPIO; WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2123229 A (GENERAL ELECTRIC CO) see 12 Fig 1	
X	GB 2015307 A (SCHLUMBERGER) see 120 Fig 3 and 300 Fig 8	1, 9 and 11 at least
A	US 5631587 (PERICOM) see 500 Fig 6	
X	US 4479091 (ALPS ELECTRIC) see 10, 11 Fig 5	1, 9 and 11 at least
X	US 4243941 (MOTOROLA) see 107, 108 The Fig	1, 9 and 11 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family

A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

PCT REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office only

International Application No.

09/913418

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) CM00565P/PCT

Box No. I TITLE OF INVENTION
Frequency Tracking Loop and Method of Frequency Tracking

Box No. II APPLICANT

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

Motorola Limited
Jays Close, Viabes Industrial Estate
Basingstoke
Hampshire RG22 4PD
United Kingdom

☐ This person is also inventor.

Telephone No. 44 1256 358211

Facsimile No.

Teleprinter No.

State (i.e. country) of nationality: GB

State (i.e. country) of residence: GB

This person is applicant ☐ all designated ☒ all designated States except ☐ the United States ☐ the States indicated for the purposes of: States the United States of America of America only in the Supplemental Box

Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

AFTELAK, Andrew John
54 Ivor Gardens
Lychpit
Basingstoke
Hampshire **RG24 8YD** **GB**

This person is:

☐ applicant only
☒ applicant and inventor
☐ inventor only (if this check-box is marked, do not fill in below.)

State (i.e. country) of nationality: GB

State (i.e. country) of residence: GB

This person is applicant ☐ all designated ☐ all designated States except ☒ the United States ☐ the States indicated for the purposes of: States the United States of America of America only in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf

of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country)

Litchfield, Laura
Motorola European Intellectual Property Operations
Midpoint, Alencon Link, Basingstoke
Hampshire RG21 7PL, United Kingdom

Telephone No.
0044 1256 790 384

Facsimile No.
00441256 811 319

Teleprinter No.

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

- ☐ AP ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | |
|---|---|
| <input type="checkbox"/> AE United Arab Emirates | <input type="checkbox"/> LR Liberia |
| <input type="checkbox"/> AL Albania | <input type="checkbox"/> LS Lesotho |
| <input type="checkbox"/> AM Armenia | <input type="checkbox"/> LT Lithuania |
| <input type="checkbox"/> AT Austria | <input type="checkbox"/> LU Luxembourg |
| <input checked="" type="checkbox"/> AU Australia | <input type="checkbox"/> LV Latvia |
| <input type="checkbox"/> AZ Azerbaijan | <input type="checkbox"/> MA Morocco |
| <input type="checkbox"/> BA Bosnia and Herzegovina | <input type="checkbox"/> MD Republic of Moldova |
| <input type="checkbox"/> BB Barbados | <input type="checkbox"/> MG Madagascar |
| <input type="checkbox"/> BG Bulgaria | <input type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BR Brazil | <input type="checkbox"/> MN Mongolia |
| <input type="checkbox"/> BY Belarus | <input type="checkbox"/> MW Malawi |
| <input checked="" type="checkbox"/> CA Canada | <input type="checkbox"/> MX Mexico |
| <input type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> NO Norway |
| <input checked="" type="checkbox"/> CN China | <input type="checkbox"/> NZ New Zealand |
| <input type="checkbox"/> CR Costa Rica | <input checked="" type="checkbox"/> PL Poland |
| <input type="checkbox"/> CU Cuba | <input type="checkbox"/> PT Portugal |
| <input checked="" type="checkbox"/> CZ Czech Republic | <input type="checkbox"/> RO Romania |
| <input type="checkbox"/> DE Germany | <input type="checkbox"/> RU Russian Federation |
| <input type="checkbox"/> DK Denmark | <input type="checkbox"/> SD Sudan |
| <input type="checkbox"/> DM Dominica | <input type="checkbox"/> SE Sweden |
| <input type="checkbox"/> EE Estonia | <input checked="" type="checkbox"/> SG Singapore |
| <input type="checkbox"/> ES Spain | <input checked="" type="checkbox"/> SI Slovenia |
| <input type="checkbox"/> FI Finland | <input type="checkbox"/> SK Slovakia |
| <input type="checkbox"/> GB United Kingdom | <input type="checkbox"/> SL Sierra Leone |
| <input type="checkbox"/> GD Grenada | <input type="checkbox"/> TJ Tajikistan |
| <input type="checkbox"/> GE Georgia | <input type="checkbox"/> TM Turkmenistan |
| <input type="checkbox"/> GH Ghana | <input type="checkbox"/> TR Turkey |
| <input type="checkbox"/> GM Gambia | <input type="checkbox"/> TT Trinidad and Tobago |
| <input type="checkbox"/> HR Croatia | <input type="checkbox"/> TZ United Republic of Tanzania |
| <input checked="" type="checkbox"/> HU Hungary | <input type="checkbox"/> UA Ukraine |
| <input type="checkbox"/> ID Indonesia | <input type="checkbox"/> UG Uganda |
| <input checked="" type="checkbox"/> IL Israel | <input checked="" type="checkbox"/> US United States of America |
| <input checked="" type="checkbox"/> IN India | <input type="checkbox"/> UZ Uzbekistan |
| <input type="checkbox"/> IS Iceland | <input type="checkbox"/> VN Viet Nam |
| <input checked="" type="checkbox"/> JP Japan | <input type="checkbox"/> YU Yugoslavia |
| <input type="checkbox"/> KE Kenya | <input type="checkbox"/> ZA South Africa |
| <input type="checkbox"/> KG Kyrgyzstan | <input type="checkbox"/> ZW Zimbabwe |
| <input type="checkbox"/> KP Democratic People's Republic of Korea | |
| <input type="checkbox"/> KR Republic of Korea | |
| <input type="checkbox"/> KZ Kazakhstan | |
| <input type="checkbox"/> LC Saint Lucia | |
| <input type="checkbox"/> LK Sri Lanka | |

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

- ☐
 ☐

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Supplemental Box*If the Supplemental Box is not used, this sheet should not be included in the request.*

1. If, in any of the Boxes, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:

- (i) if more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;
- (ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;
- (iii) if, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of all designated States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;
- (iv) if, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;
- (v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "continuation" or "Continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;
- (vi) if, in Box No. VI, there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.
- (vii) if, in Box No. VI, the earlier application is an ARIPO application: in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.

2. If, with regard to the precautionary designation statement contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded

3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty: in such case, write "Statement concerning non-prejudicial disclosures or exceptions to lack of novelty" and furnish that statement below

Continuation of Box No. IV

TRELEVEN, Colin
 IBBOTSON, Harry
 MORGAN, Marc
 POTTS, Susan
 DUNLOP, Hugh

All above attorneys/agents are members of Motorola, Inc., Intellectual Property Department and have the same address, telephone number and telegraphic address as indicated in Box IV.

Box No. VI PRIORITY CLAIM		Further priority claims are indicated in the Supplemental Box <input type="checkbox"/>	
Priority of the following earlier application(s) is claimed:		Office where earlier application filed	
Filing Date of earlier application (day/month/year)	Number of earlier application	National application = country; regional application = regional Office	International application = receiving Office
item (1) 26 February 1999	9904437.2	GB	
item (2)			
item (3)			

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s):

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used): ISA/ EP

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year) _____ Number: _____ Country (or regional office): _____

Box No. VIII CHECK LIST; LANGUAGE OF FILING

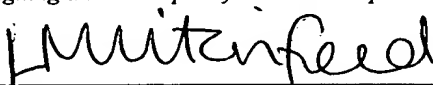
This international application contains the following number of sheets: 1. request : 4 sheets 2. description (excluding sequence listing part) : 13 sheets 3. claims : 3 sheets 4. abstract : 1 sheets 5. drawings : 2 sheets 6. sequence listing part of description : sheets Total : 23 sheets	This international application is accompanied by the item(s) marked below: 1. <input type="checkbox"/> fee calculation sheet 2. <input type="checkbox"/> separate signed power of attorney 3. <input type="checkbox"/> copy of general power of attorney 4. <input type="checkbox"/> statement explaining lack of signature 5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): 6. <input type="checkbox"/> translation of international application into (language): 7. <input type="checkbox"/> separate indications concerning deposited microorgs./biological mat. 8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form 9. <input type="checkbox"/> other (specify): copy, U.S. assignment
--	--

Figure No. 2 of the drawings (if any) should accompany the abstract when it is published.

Language of filing of the international application: EN

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

LAURA LITCHFIED 

For receiving Office use only

1. Date of actual receipt of the purported international application: 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: 4. Date of timely receipt of the required corrections under PCT Article II(2): 5. International Searching Authority specified by the applicant: ISA/	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received: 6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid
--	---

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Date of receipt of the record copy by the International Bureau:	
---	--

Form PCT/RO/IOT (last sheet) (July 1998)

This sheet is not part of and does not count as a sheet of the international application.

See Notes to the request form

International application

Date Stamp of the receiving Office

Applicant's or agent's file reference	CM00565P/PCT
--	--------------

Applicant	Motorola Limited
-----------	-------------------------

CALCULATION OF PRESCRIBED FEES

- | | | |
|----|--|--|
| 1. | TRANSMITTAL FEE | 200 DM T |
| 2. | SEARCH FEE | 2200 DM S |
| | International search to be carried out by <u>ISA/EP</u>
<i>(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)</i> | |
| 3. | INTERNATIONAL FEE | |
| | Basic Fee | |
| | The international application contains <u>23</u> sheets. | |
| | first 30 sheets | 800 DM b₁ |
| | <u>0</u> X _____ = <u>0</u> | b₂ |
| | remaining sheets additional amount | |
| | Add amounts entered at b ₁ and b ₂
and enter total at B | 800 DM B |
| | Designation Fees | |
| | <u>8</u> X <u>184</u> | <u>1472DM</u> D |
| | number of designations amount of designation fee payable (maximum 10) | |
| | Add amounts entered at B and D and enter total as I | _____ I |
| | <i>(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled the total to be entered at I is 25% of the sum of the amounts entered at B and D.)</i> | |
| 4. | FEE FOR PRIORITY DOCUMENT (if applicable) | _____ P |
| 5. | TOTAL FEES PAYABLE | |
| | Add amounts entered at T, S, I and P,
and enter total in the TOTAL box | 4672 DM |

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

- | | | | | | |
|-------------------------------------|-----------------------------|--------------------------|----------------|--------------------------|---------------------------|
| <input checked="" type="checkbox"/> | authorization to charge | <input type="checkbox"/> | bank draft | <input type="checkbox"/> | coupons |
| | deposit account (see below) | | | | |
| <input type="checkbox"/> | cheque | <input type="checkbox"/> | cash | <input type="checkbox"/> | other (<i>specify</i>): |
| <input type="checkbox"/> | postal money order | <input type="checkbox"/> | revenue stamps | | |

DEPOSIT ACCOUNT AUTHORIZATION

The RO/ EP

☒ is hereby authorized to charge the total fees indicated above to my deposit account

☒ is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☒ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

28050071

25 February 2000

Deposit Account Number

Date (day/month/year)

Signature

LAURA LITCHFIED

09/913416

04 DEC 2000
PCT PATENT
DEPT.From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

MORGAN, M.
MOTOROLA
European Intellectual Property
Operations
Midpoint, Alencon Link
Basingstoke
Hampshire RG21 7PL
GRANDE BRETAGNE

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing
(day/month/year) 30.11.2000

Applicant's or agent's file reference
CM00565P/PCT

IMPORTANT NOTIFICATION

International application No.
PCT/EP00/01734

International filing date (day/month/year)
25/02/2000

Priority date (day/month/year)
26/02/1999

Applicant
MOTOROLA LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

*nothing docketed pass
to CT/MM.*

DOCKETED
EIPO
- 6 DEC 2000

Name and mailing address of the IPEA/

 European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Röhner, M

Tel. +49 89 2399-2294



PCT

REC'D 04 DEC 2000

WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

10

Applicant's or agent's file reference CM00565P/PCT		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/01734	International filing date (day/month/year) 25/02/2000	Priority date (day/month/year) 26/02/1999	
International Patent Classification (IPC) or national classification and IPC H03J7/04			
Applicant MOTOROLA LTD. et al.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 7 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 04/09/2000	Date of completion of this report 30.11.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Kurzbauer, W Telephone No. +49 89 2399 7479



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01734

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

Description, pages:

1-13 as originally filed

Claims, No.:

1-15 as originally filed

Drawings, sheets:

1/2-2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/EP00/01734

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 15.

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 15 are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination report cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Yes: Claims 1-14

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01734

	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-14
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. In **claim 15** reference is made to Figure 9. According to Rule 6.2 PCT claims shall not rely on such references.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

2. Reference is made to the following document:

D1: US-A-4 691 176 (HSIUNG CHIA Y ET AL) 1 September 1987 (1987-09-01)

3. The subject matter of claim 1 concerns a frequency tracking loop for a digital radio communications system. The posed problem is to provide optimum frequency tracking in a feedback tracking loop.

The document D1 is regarded as being the closest prior art to the subject-matter of claim 1 insofar as this claim can be understood (see Section VIII).

Document D1 discloses an adaptive carrier circuit for receiving pulse code modulated communications. A frequency tracking loop for eliminating a frequency offset is also disclosed.

However, the methods and circuits disclosed in document D1 do not comprise a circuit, where the output of a frequency offset estimator is filtered by a variable bandwidth filter and where the bandwidth of said filter is adapted in dependence of at least one characteristic of a received burst of a training sequence and no argumentation could be found why a person skilled in the art knowing D1 would modify the disclosed circuit and add features such that he arrives at the subject matter of claim 1.

A similar reasoning is also valid for the corresponding method claim 11 which claims essentially the same features as claim 1.

Consequently, **claim 1 and claim 11** fulfill the requirements of the PCT

concerning novelty and inventive step.

4. **Claims 2 to 10** are dependent on claim 1 and **claims 12 to 14** are dependent on claim 11. These dependent claims therefore also fulfill the requirements of the PCT concerning novelty and inventive step.

Re Item VII

Certain defects in the international application

5. The features of the claims are not provided with **reference signs** placed in parentheses (Rule 6.2(b) PCT).
6. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

Re Item VIII

Certain observations on the international application

7. It is not clear in **claims 1 and 11 (and in the corresponding dependent claims)** what is meant by the term '**known data**' (Article 6 PCT).
As each input signal, apart from noise, represents, in fact, known data, the reader is left in doubt what is actually meant by the term.
It is therefore suggested to replace the term 'known data' by '**training sequence**' as described on page 3, line 22 in the description part of the application.

Miscellaneous

When filing amended claims the applicant should at the same time bring the **description into conformity with the amended claims** (Rule 5.1(a)(iii) PCT).

Care should be taken during revision **not to add subject-matter which extends beyond the content of the application as originally filed** (Article 19(2) and 34(2) (b), PCT).

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/EP00/01734

In order to facilitate the examination of the conformity of the amended application with the requirements of Article 34(2)(b) PCT, the applicant is requested to clearly **identify the amendments carried out**, no matter whether they concern amendments by addition, replacement or deletion, and to indicate the passages of the application as filed on which these amendments are based (see also Rule 66.8(a) PCT).

If the applicant regards it as appropriate these indications could be submitted in handwritten form on a copy of the relevant parts of the application as filed.

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
MOTOROLA
European Intel. Property Operations
Attn. LICHTFIELD, Laura
Midpoint, Alencon Link
Basingstoke
Hampshire RG21 7PL
UNITED KINGDOM

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

EUROPEAN

(PCT Rule 44.1)

11 AUG 2000

Date of mailing
(day/month/year)
11/08/2000

Applicant's or agent's file reference

CM00565P/PCT

FOR FURTHER ACTION

See paragraphs 1 and 4 below

International application No.

PCT/EP 00/ 01734

International filing date
(day/month/year)

25/02/2000

Applicant

MOTOROLA LTD. et al.

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

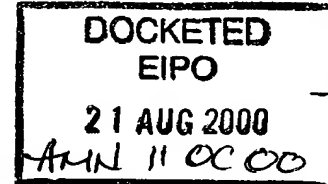
Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.



Send to have

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority



European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Mareike Zambuto

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.